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The Psychological Reality of NP-Trace

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A large part of the investigation of syntactic structure concerns long-distance coreferential dependencies, currently treated in government and binding syntax via empty categories (Chomsky, 1981). The distribution and proper treatment of empty categories has become a controversial topic which differentiates the internal structure of different syntactic theories, which are similar in many other regards. For this reason, considerable attention has recently been given to extending the empirical basis for empty categories. In this paper, we briefly review the evidence as it stands now, and present new evidence confirming the processing relevance of NP-movement trace as postulated within government and binding theory.

Empty categories can be thought of as implicit anaphors, linguistic entities which have no intrinsic content except to refer back to an antecedent that is related to them by an appropriate grammatical structure. We can differentiate three major kinds of empty categories: wh-gaps (1a), raising-gaps (1b), and control gaps (1c).

- (1a) This is the book that I like [t]
- (1b) Harry seemed [t] to be sad
- (1c) Harry wanted [PRO] to be happy

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From the standpoint of comprehension processes, these three kinds of gaps have markedly different properties. Wh-gaps explicitly mark the antecedent (in English, usually with a wh word) as needing the gap in order to be assigned a thematic role. Raising-gaps characteristically change the thematic role that a comprehension mechanism may have already assigned to the antecedent noun phrase. Finally, control gaps allow the antecedent to maintain its initially assigned thematic role in relation to one predicate, but also to serve as an argument for a second predicate. If the initial stages of comprehension involve assigning thematic roles to phrases, then the three kinds of empty categories should have distinct behavioral characteristics. Wh-gaps should access their antecedent immediately at the point of the gap since it is only then that the antecedent can be assigned any thematic role at all. Raising-gaps may access their antecedent more slowly because this involves undoing a thematic role which is already assigned and assigning a different thematic role to the antecedent. Finally, control gaps may show the smallest amount of access since they are related to their antecedent essentially only at the level of semantic description and not at the structural level.

In sum, a behavioral measure of the extent to which an anaphor has accessed a structural representation of its antecedent should reveal that wh-gaps have the strongest access, raising-gaps an intermediate amount of access, and control gaps the least amount. Data collected from several different laboratories, using somewhat different techniques, seem to confirm this general hypothesis. The main technique is to measure the extent to which a target word is primed in a behavioral task. For example, Nicol and Swinney (1989) auditorally present wh-gap sentences schematically like those in (1a) to subjects. At some point during the sentence, a letter sequence appears on the screen, which the subject must identify as a word or not. In the critical case, the probe word is either semantically associated to the wh-antecedent or not. The relative speed to identify the word when it is related to the antecedent is a measure of the mental priming. Nicol and Swinney report that immediately after the wh-gap, its antecedent is primed.² The immediate access of antecedents at the point of wh-gaps has been confirmed by other behavioral and electrophysiological techniques (Tanenhaus et al., 1989).

The relevance of wh-gaps to ongoing processing supplements the linguistic evidence for them. However, most current syntactic theories agree in giving special status to the description of long-distance dependency between a wh-gap and its antecedent. Thus, while the confirmation of wh-gaps as relevant to processing confirms the relevance of linguistic analyses, it does not differentiate between grammars. The treatment of NP-movement gaps within government and binding theory does present a specific mechanism which differentiates it from most other syntactic

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theories that are current. The treatment of passive constructions is a clear and striking example: it has consistently been the case in the history of generative grammar that the surface structure subject of a passive is moved from a deep structure object position. Thus, while the details of the mechanism have changed as the theory has evolved, it has remained the case that there is an inner level of representation at which the surface structure subject of a passive construction is "located" or "linked to an anaphor" in the object position. Bever and McElree (1988) tested the processing relevance of this structural analysis with a slightly different priming technique from that used by Nicol and Swinney. Their experimental technique involves a word-recognition paradigm from Cloitre and Bever (1988); subjects read a short discourse on a computer screen, pacing themselves one phrase at a time. At an unexpected point, a word appears at a different screen position, and the subject must quickly indicate whether the word was in the discourse or not. In this case, recognition times are contrasted using minimal syntactic pairs with and without an NP-trace. For example, trace-priming is inferred if the latency to recognize the adjective 'shrewd' is faster in (2b) than in (2a) or in (3b) than (3a).

- (2a) The shrewd lawyer...had spoken to the judge : SHREWD
- (2b) The shrewd lawyer...was suspected [t] by the judge

- (3a) The shrewd lawyer...was resentful constantly
- (3b) The shrewd lawyer...was resented [t] constantly

In a series of studies using such materials and passive constructions of different kinds, McElree and Bever (1989) found that a few words after the trace, passive subjects are primed. The priming of passive subjects has been replicated in several other laboratories using priming techniques of slightly different kinds (MacDonald, 1989; Nicol & Osterhout, ms.).

The finding that the surface structure subject of a passive sentence is primed by the end of the sentence is consistent with the hypothesis that it is linked to a trace which occurs near the end of the sentence. However, this result is also consistent with several other interpretations of how the priming process works. The most salient alternative interpretation is that the passive construction (by definition) places its surface structure subject in focus at the discourse level of representation. To rule out the possibility that the subject priming in passive is a discourse focus phenomenon, McElree and Bever (1989) contrasted constructions with NP-movement, raising (4c), against constructions with control anaphors (4b) and with no anaphor at all (see examples in (4a)).

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- (4a) The shrewd lawyer...was rude to the rehearsers
- (4b) The shrewd lawyer...was eager PRO to rehearse
- (4c) The shrewd lawyer...was sure [t] to rehearse

They used the same word recognition technique as before. They found that the raising constructions primed their antecedents significantly compared with both the PRO construction and the non-anaphor control constructions. This result confirmed a previous experiment (Bever & McElree, 1988) which contrasted raising and other cases using raising verbs (such as "seem") rather than raising adjectives. There is no obvious way in which raising constructions lend discourse focus more strongly to their surface structures than do the corresponding constructions with which they form minimal pairs.

It is important to note that all the preceding results support the trace analysis of syntactic passive and raising on a particular linking assumption, which states the relation between traces and behavior: a trace accesses a mental representation of its antecedent. This, in turn, results in greater priming of the antecedent either because the antecedent has a double representation, or a recent one (or both). The priming studies have supported the trace hypothesis, and the related linking hypothesis. However, the use of minimal pairs means that there is always a lexical difference between every trace construction and its corresponding non-trace control sentence. There are, of course, corresponding semantic and structural distinctions as well. Thus, the previous results could be explained by the hypothesis that some property of trace constructions speeds all lexical recognition processes. For such reasons, as well as general methodological prudence, it is important to use a converging methodology. We have been experimenting with a new technique which allows us to predict that the processing of certain words will be enhanced by their being recently primed, while the processing of other words will be relatively impeded if they have just been primed. Cloitre and Bever (1988) reported such an effect following pronominal anaphors. In particular, they found the priming of concrete adjectives from antecedents is stronger following an explicit anaphor, compared with abstract adjectives: there is no difference between abstract and concrete adjectives following corresponding non-anaphor constructions. The mechanism which mediates the difference in priming between abstract and concrete words is not well understood, although the phenomenon is quite pervasive. For our present purposes, we test the assumption that if a word is primed in a particular construction, its recognition time will be longer if it is an abstract word than if it is a concrete word. This contrasts with the prediction that the same abstract/concrete difference will not appear for words which have not been primed. We developed a set of adjective pairs matched for frequency and length in which one adjective is intuitively abstract

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("shrewd, nice") and one is intuitively concrete ("tall, pretty"). We then contrasted the word recognition latency for the abstract and concrete adjectives: following Cloitre and Bever (1988) the prediction was that the abstract/concrete difference in recognition time would appear only when the adjective was recently primed by a trace.

We first validated this prediction on cases of syntactic passive constructions which we have previously shown to prime their surface structure subjects.⁶ The results clearly followed the prediction (Table 1): the difference in reaction time to recognize abstract and concrete adjectives from the surface structure subject following a syntactic passive construction was much larger than the difference following the corresponding active constructions. This result supports the behavioral claim that priming is specific to the surface structure subject in the passive, rather than an enhancement of the recognition of all words.

In part of this study, we also contrasted 16 syntactic and 8 adjectival passives.⁷ This contrast is important since subjects of adjectival passives are argued to be lexically generated as subjects at deep structure, without movement or trace. MacDonald (1989) reports significantly more recognition priming of surface subject nouns following syntactic passives, compared with adjectival passives. Our results converge with hers: adjectival passives did not elicit an abstract/concrete difference (Table 1). This result strengthens further the case for the trace analysis of the passive construction as a syntactic phenomenon rather than a reflection of discourse: adjectival passive constructions seem prima facie to focus their surface subject as much as syntactic passive constructions, yet they show no abstract/concrete priming effect.

To investigate further the claim that it is specifically trace which occasions the abstract/concrete priming effect, we contrasted the priming of surface structure subjects of sentences involving simple transitive verbs and "psych-ergative" verbs such as those contrasted below.

- (5a) The shrewd lawyer....attacked the judge
- (5b) The shrewd lawyer....surprised [t] the judge
- (5c) The shrewd lawyer....was attacked [t] by the judge
- (5d) The shrewd lawyer....was surprised by the judge

Throughout the history of generative grammar, it has been noted that psych-ergative verbs have properties which suggest that their surface subject is actually raised from logical object position. The contrast between psych-ergatives and transitive verbs allows the construction of a set of materials which are well matched for surface properties, such as in the paradigm below (6).

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- (6a) The shrewd lawyer....attacked the judge
- (6b) The shrewd lawyer....surprised [t] the judge
- (6c) The shrewd lawyer....was attacked [t] by the judge
- (6d) The shrewd lawyer....was surprised by the judge

If the trace analysis of psych-ergatives is correct, then the pattern of results for active and passive constructions should be the reverse for sentences involving psych-ergative verbs than sentences involving simple transitive verbs. This is because it is in the active construction that the psych-ergative verbs have a trace and not the passive. We probed for the abstract/concrete adjective recognition time difference in a study using the same paradigm as before. The results very strongly show the predicted differences (Table 1). In particular, the abstract/concrete adjective recognition time difference was extremely large following the syntactic passive and the psych-ergative active constructions, and negligible following the other constructions.

These results take us a step further in our argument that it is truly the presence of a trace which primes its antecedents, rather than some particular surface property of trace constructions. Specifically, we were able to contrast two "active" constructions, one of which has a presumed trace and the other does not, and find that the one with the trace gives evidence of accessing the surface structure subject. Correspondingly, we were able to contrast two "passive" constructions and show that only in the one which syntactically accesses its surface structure subject is there a priming effect. Thus, the priming effects we originally reported cannot be due to a discourse or other behavioral property of the superficial "passive" construction, nor to a special property of the superficial "active" construction.

We believe that the aggregate of these studies are a further demonstration that cases which are analyzed syntactically as having traces are processed behaviorally as though there were anaphors corresponding to the traces. Syntactic theories come and go. Thus, we think that the enduring value of the research effort we have described in this paper is to reconfirm the processing relevance of a syntactic and sentence-based set of structural distinctions. It is also tempting to argue from this research that it uniquely confirms and extends the psychological basis of the government and binding framework of syntactic analysis. But, we are sure that other syntactic theories can be shown to make structural distinctions which correspond in relevant ways to the structural distinctions reflected by the distribution of trace in government and binding analyses. This follows from the fact that we have attempted to study only those cases of trace analysis for which there are distributional arguments. Other syntactic theories must respect in their own way the significance of the

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distributional differences which are explained by the postulation of NP-movement and traces. For example, many grammatical theories which do not postulate a syntactic mechanism corresponding to NP-trace constructions might well group and differentiate the corresponding constructions in a parallel way at a semantic level of representation. Thus, our results might be taken to support the psychological validity of priming from semantic processes and representations of syntactic passives, raising constructions and psych-ergative actives. This interpretation would require a semantic theory that groups the trace constructions, and a linking behavioral theory of how these constructions prime their surface structure subjects. We must admit the possibility that such a unified semantic explanation of our findings might be available (though we cannot think of one). However, it is not clear what linking hypothesis would result in the unifying semantic factors being reflected in subject priming differences. Ultimately, insofar as one can use psychological evidence of the reality of a particular syntactic framework, the argument will not come down to which grammatical theory makes the right distinctions. Rather, the argument will come down to the question of how naturally the way in which the syntactic theory renders the distinctions can be embedded within a behavioral theory. At the moment, we think that government and binding analyses and the linking assumption that traces act behaviorally as anaphors, provide the simplest explanation for the data we have presented.

Footnotes

1. This paper is primarily addressed to an audience of linguists.

Hence, our description of experimental details is attenuated and awaits full presentation elsewhere. We assume the raising NP-trace analyses for syntactic passive, raising, and psych-ergative actives. We recognize that these claims are controversial to some extent, even among linguists committed to a government and binding framework. The appended bibliography on the relevant topics reflects the ferment over these issues, but we intend no commentary on the linguistic literature at the moment.

2. Nicol and Swinney (1989) measure priming of an antecedent by presenting a word that is a semantic associate of the antecedent head phrase and asking subjects to decide whether the word is a word or not. They contrast this with the amount of time it takes

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to decide about another word which is not related associatively to the antecedent. This technique has the great virtue of not explicitly requiring the subjects to think about the sentence as part of the prime-recognition task. On the other hand, the technique involves a large number of methodological jokers: first, it relies on semantic association between the antecedent and the target word; second, the lexical decision itself takes a considerable amount of time, and may lead to so-called "integration" effects. (In other words, an interpretation of their results is that subjects noticed there is a gap position and then used the backward association from the prime back to the antecedent.) Finally, although they report which positions show priming and which do not, they do not characteristically report the significance of the difference in the amount between positions where in theory there should be priming and there should not. This often leaves it unclear whether the "primed" positions are actually significantly different from the "non-primed" positions.

3. See Cloitre and Bever (1988) and McElree and Bever (1989) for experimental details. All the studies reported in this paper used the same technique.

(1) Design. We present results from two new experiments reported in this paper. The first, run at MIT by J.J.K., with 17 analyzed subjects, contrasted only syntactic passive and corresponding actives (e.g., 2a, 2b). There were 12 critical sentence pairs in this study. The second study, run at Rochester by K.S. and K.S., with 24 analyzed subjects, contrasted passive and active constructions with transitive and psych-ergative verbs, in 24 sets like [6a-d]. The distinction between syntactic and non-syntactic passive transitive verbs in this study was a materials variable, with 8 sentence sets having syntactic passives and 16 having adjectival passives (other than psych-ergatives). Sets of experimental materials were designed so that each subject responded to one version from each set (e.g., 2a or 2b in Experiment 1, 6a or b or c or d in Experiment 2). Across sets, each subject responded to the same number of construction types. Each experimental set of sentences contained more than 50 padding trials: as in Cloitre and Bever (1988) these trials were designed to prevent subjects from focussing on adjective probes after single sentences. Some of the padding materials were negative trials, in which the probe word was not in the preceding discourse; some were two sentences long, some only a single sentence fragment; most had non-adjective probes. All critical experimental sentences had human subjects and objects.

(2) Procedure: On each trial, the subjects paced themselves

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through the stimuli, presented phrase-by-phrase, with a new phrase wiping out the preceding one in the center of the screen each time subject pressed a button. The sentences were broken into 2-5-word phrases at natural points, such that the object phrase in actives and the "by" phrase in passives were separate phrases (indicated by slashes in 2b' below). The probe word was presented in capital letters; it always appeared at the end of the sentence in critical cases. Following the probe recognition task, subjects were presented with forced-choice questions about the short discourse.

- (3) **Subjects:** Subjects were all native speakers of English attending college, with verbal SAT scores above 550. About 20% of subjects originally run were dropped from data analysis on the grounds that they performed poorly, either on the probe recognition or the comprehension task.

In all experimental sentences, there was a relative clause intervening between the subject phrase and the verb (indicated by "...." in our examples). For example, (2b) actually was (2b'). "The shrewd lawyer/who was standing/in the hallway/was suspected/by the judge".

Although this research is preliminary, the results are statistically reliable in the crucial cases. (All means are based on correct recognition responses only: responses greater than 2 1/2 standard deviation from the subject's mean were replaced by the value of 2 1/2 S.D.) First, a paired t-test across all subjects shows that the abstract/concrete probe recognition latency difference is larger in all the NP-trace constructions than in the corresponding non-trace constructions ($p < .0035$, 1-tail). More specifically, syntactic passive elicits more abstract/concrete difference than the corresponding active ($p < .05$, counting subjects from both experiments). Psych-ergative active elicits more abstract/concrete difference than its corresponding psych-ergative passive ($p < .01$), and more than transitive actives ($p < .03$). Most important, in Experiment 2, the construction type (passive vs. active) by verb type (psych-ergative vs. transitive) interaction was significant ($p < .02$).

4. MacDonald (1989) used a noun recognition paradigm similar to the paradigm we have described. Osterhout and Nicol report a weak and late, but extant priming effect of passive trace, using the lexical decision task described in Nicol and Swinney (1989).

5. Notice that if it does turn out to be the case that the raising constructions also increase discourse focus, the results will still support the argument for trace. In particular, it may be that the

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NP-movement and wh-movement are in fact the sentential mechanisms which account for discourse focus. In addition, if recent proposals are correct that all subjects are raised from within their verb phrase, this would explain structurally the usual processing prominence of subjects.

6. We use the same kind of word recognition paradigm described above.

7. We used several typical tests to choose adjectival and syntactic passives: in particular, can the passive-adjectival be prenominal ("the ruined town/*the attacked town"), can it be predicated with verbs after the "be" ("the town looked ruined/*attacked"), can it be used as a completive ("the town ended up ruined/*attacked").

8. Chomsky (1965) suggests that the passive of psych-ergative verbs is actually a stylistic variant of the corresponding adjectival constructions. Postal (1971) argued that psych-ergative verbs are in the class of so-called "flip" constructions in which the deep structure subject and object actually exchange places to form the active construction.

9. We are exploring the priming effects of unaccusatives and unergatives in English and Italian as a way of differentiating whether priming effects are semantic or due to trace. The unaccusative/unergative semantic differences are presumably the same in all languages, but only in Italian are there strong arguments for movement and NP-trace uniquely in unaccusatives. If the priming is caused by syntactic trace, unaccusatives should elicit more priming than unergatives in Italian, but there should be no difference in English. Our initial experimental studies suggest that there is, in fact, no difference in subject priming for the two constructions in English, while in Italian there may be. We are pursuing this further.

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THE PSYCHOLOGICAL REALITY OF NP-TRACE

TABLE 1

Probe-word recognition time for differences (in milliseconds)
 between abstract and concrete words following different constructions
 (Abstract Recognition Latency) - (Concrete Recognition Latency)

Trace Constructions	Abs/Conc Difference
Syntactic Passive	103
Psych-ergative active	166
Non-Trace Constructions	
Transitive active	-15
Adjectival passive	10
Psych-ergative passive	-41